SOME FEATURES OF THE TRIBUTARIES TO LAKE SUPERIOR IN NORTHEASTERN MINNESOTA

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More than thirty streams, extending from Duluth to the Pigeon River, along the north shore of Lake Superior, flow from the upland into this lake. Many of these have falls and rapids in their lower courses. They either rise in glacial lakes or marshes or flow through them, having broad, boulder-strewn channels but at a comparatively short distance from the lake, their gradients are steep. Here they cut deep, narrow gorges through the basalt flows, diabase dikes and sills of Keweenawan age. The streams have taken advantage of the vertical jointing and the weaker amygdaloidal zones in excavating their channels. Numerous well-developed potholes are found along the courses of some of the streams. The waterfalls and cascades are of exceptional beauty.

The rejuvenation of the streams which is responsible for the gorges, is attributed to the gradual lowering of the glacial lake levels as new outlets were opened by the recession of the Lake Superior ice-lobe, the post-glacial tilting of the land, and the deepening and widening of the Lake Superior trough by the glacier.

DESCRIPTION AND BASIC FACTS

Along the north shore of Lake Superior, the hills are close to the shoreline and cascades and waterfalls are present on many streams near their outlet. There are more than thirty rushing, tumbling streams between Duluth and the Canadian border, some of which descend as much as a thousand feet or more in their short courses to Lake Superior. The interstream divides rise to 400 feet and in some places nearly a thousand feet within a distance of a mile from the lake. There are numerous lakes at the headwaters of these streams which serve as storage reservoirs and supply a constant flow during dry seasons which adds to their value as future sources of water power.

The principal streams, named in order from Duluth to the international boundary are the Lester, Gooseberry, Beaver Bay, Baptism (Fig. 2), Manitou (Fig. 3), Cross, Temperance, Poplar, Cascade, Devil's Track, Brule and Pigeon rivers. None are large streams and their drainage areas are comparatively small. The largest is the Pigeon River (Fig. 4), which has a drainage of 628 square miles. The others, in order of size, have the following drainage areas:[2] Brule, 282 sq. mi.; Temperance, 198 sq. mi.; Poplar, 144 sq. mi.; Baptism, 135 sq. mi.; Beaver Bay, 120 sq. mi.; Gooseberry, 85 sq. mi.; Cascade, 84 sq. mi.; Devil's Track, 75 sq. mi.; Manitou, 71 sq. mi.; Lester, 55 sq. mi., and Cross, 32 sq. mi

The streams tributary to Lake Superior on the north shore flow from the upland with gradients averaging 250 feet in a distance of about one and one-half miles. The rapids and falls begin at points as close to Lake Superior as .05 mile, up to points greater than a mile. The altitude of their courses on the glaciated upland varies from 1650 to 1950 feet, averaging 1800 feet. In general, the minor tributaries on the north shore of Lake Superior have a rapid fall from source to mouth except for short distances through lakes or swamps. When traced from their outlets at Lake Superior to their sources, the general sequence of features is as follows: at the junction of the river and the lake there is usually a gravel bar

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[2]Leverett, Frank. Moraines and Shorelines of the Lake Superior Basin. U. S. Geol. Survey, Professional Paper 154, p. 11.

thrown across the mouth by the vigorous waves from the lake. Because of the absence of a bar at its mouth, the Temperance River was given its unique name. Behind the bars there may be a gentle gradient with rather quiet water for a short distance. In some instances, the falls and rapids begin not far back from the shoreline. For a distance of a mile, more or less, the streams flow through narrow gorges, leaping from ledge to ledge by cascades and waterfalls. Beyond the falls and rapids on the upland, the streams open into wide, flat-bottomed, boulder-strewn channels. Their courses on the upland do not appear to follow any definite preglacial channels and wind about through lakes and swamps, following the lines of least resistance. This condition is characteristic of immature drainage in glaciated regions.

The small tributaries to Lake Superior on the north shore, in Minnesota, are associated with some of the finest scenery in the north country. They pass through coniferous forests in deep, narrow, angular, vertically-walled gorges through which the water leaps from pothole to pothole by a series of falls or rapids. They are, in many instances, easily accessible from the highway by trails constructed by the State Highway Department.

Perhaps the most spectacular of the falls are those on the Pigeon, Manitou (Fig. 3), Temperance, Cascade, Devil's Track (Fig. 6), Brule, Gooseberry and Cross rivers. The Pigeon River has the highest falls (Fig. 4), 120 feet, and a narrow spectacular gorge in its lower course. The Temperance River is unique for its extremely narrow gorge which is less than ten feet wide in places and 50 to 75 feet deep. The thunder of the water as it passes from ledge to ledge, through openings not more than three feet wide, is awe-inspiring.

One of the most interesting features in the gorges of some of these streams is the well-developed potholes. In the courses of the Temperance and Cascade rivers these potholes are especially well displayed (Fig. 5). In the opinion of the writer, there are few places in the country where one can see a finer display of potholes. Cut out of the solid rock, their sides are smoothly polished. The gorges of the Temperance and Cascade rivers, for long distances, consist of a series of potholes, some large and others small. These streams flow through a forested region and their waters carry little material in suspension. The sediment is made up of gravel, cobblestones and boulders, mainly of glacial origin, which makes excellent material for grinding potholes in solid rock. In a number of instances, the writer found potholes from 6 inches to a foot or more in diameter, cut down vertically in the diabase for depths of two to three feet. So perfect are they that they appear to have been cut by a drill. The pebbles which served as grinding tools are still present in some of them. In some cases, the potholes are huge, being as much as 25 feet in diameter and shaped like a jug. The junction between potholes is frequently sharp and triangular in outline. At one spot in the falls of the Brule (Arrowhead) River, a large part of the water dashes down into a pothole or circular pit about 8 to 10 feet in diameter, known as the "Devil's Kettle." The water disappears from view and the place where it makes its reappearance at the surface is not visible. Hence, the belief that the pit is bottomless and has no outlet. The water probably finds an outlet to the main channel by a subterranean course, not visible at the surface. Above the gorge of the Temperance River there is evidence that the water flowed originally in a broader channel. A deep abandoned pothole occurs along the trail not far from the edge of the gorge, indicating that the stream at higher levels abandoned its course in places and sought new less resistant avenues of escape as it cut downward.

The conditions for the formation of the narrow angular gorges and potholes are ideal. The Keweenawan flows have amygdaloidal zones which are weaker and less resistant sedimentaries occur interstratified with the flows. The diabase

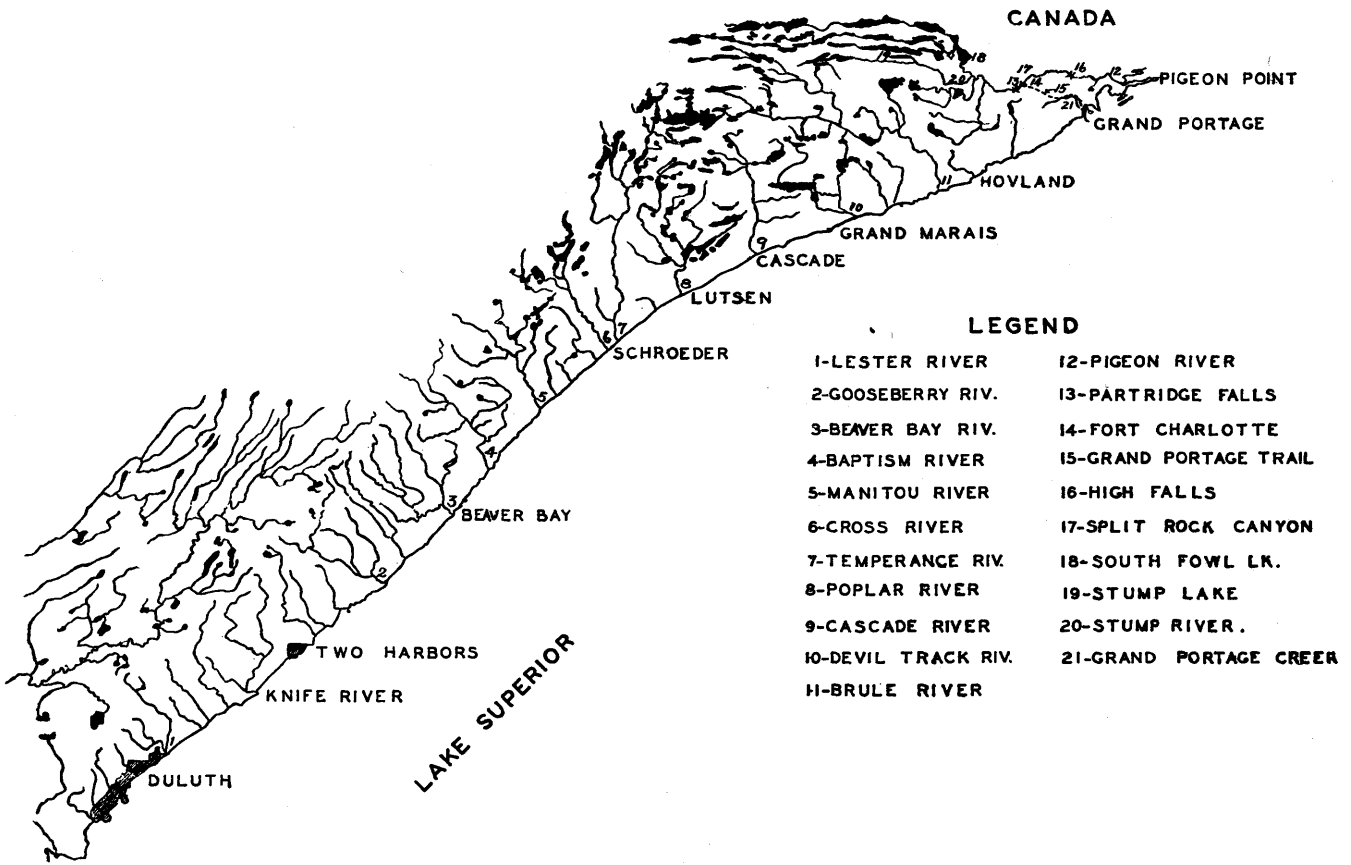

FIG. 1. A map showing some features of the tributaries to Lake Superior in northeastern Minnesota.

FIG. 2. Falls of the Baptism River.

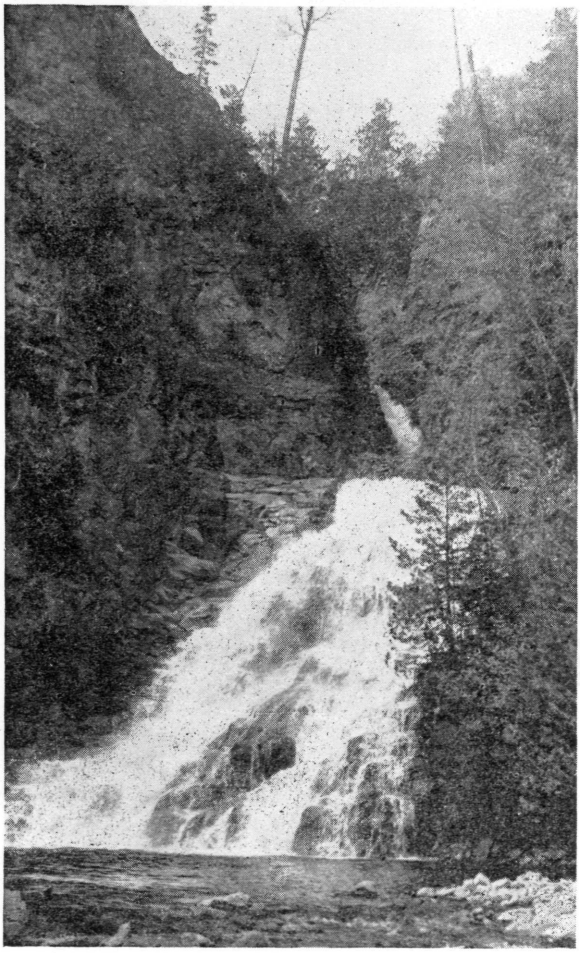

FIG. 3. Manitou Falls on Manitou River.

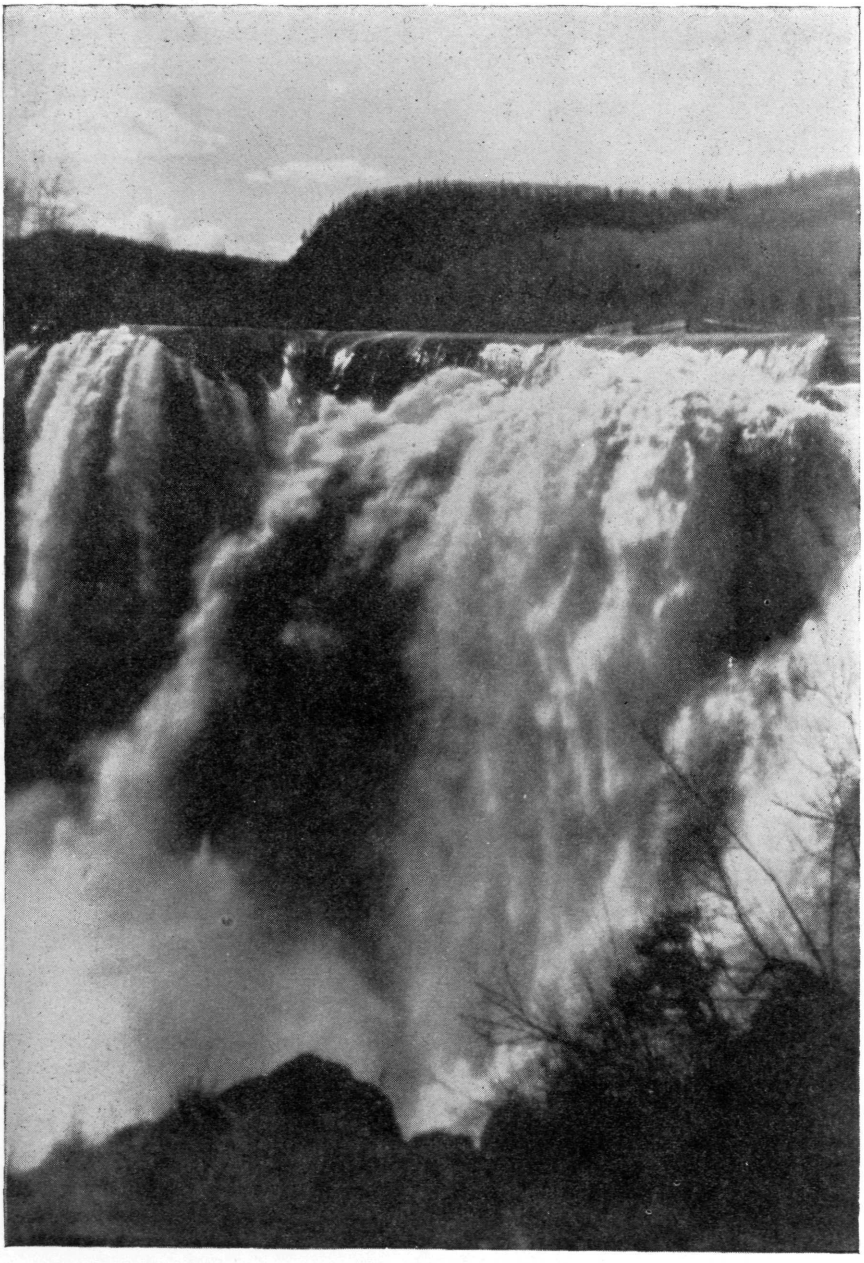

FIG. 4. High Fall on Pigeon River.

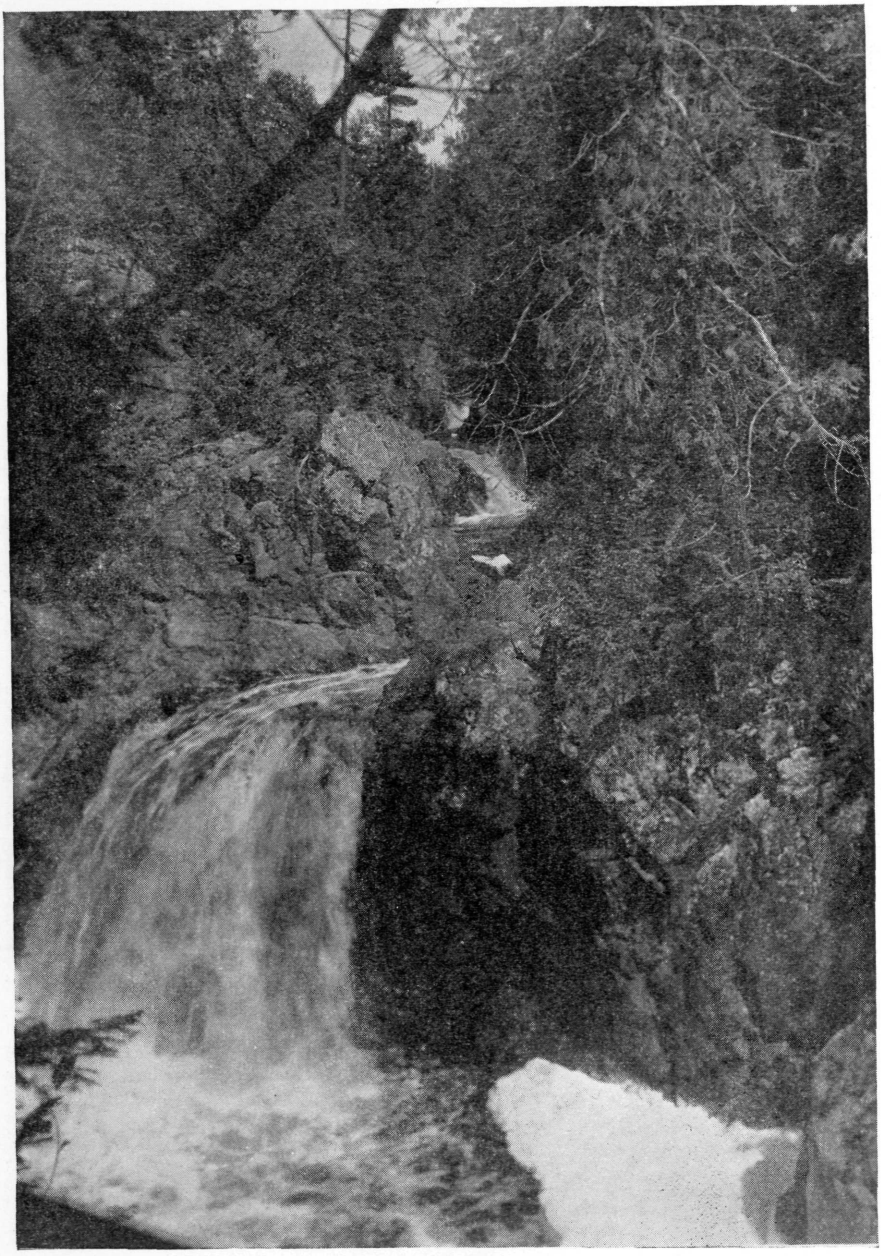

FIG. 5. Cascade Falls on Cascade River.

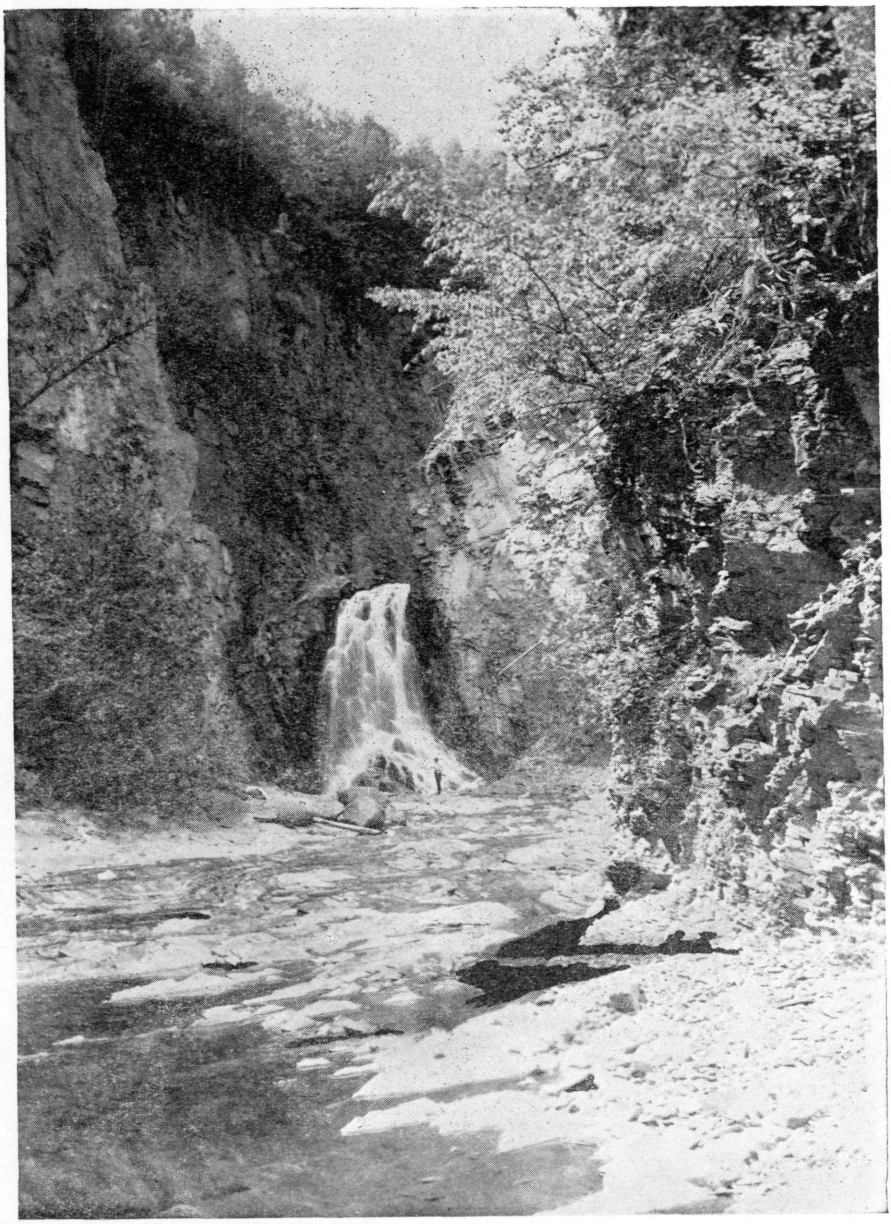

FIG. 6. Devil Track Fall on Devil Track River.

dikes and sills have well developed vertical jointing along which the streams have cut their channels.

EFFECTS OF GLACIATION

In preglacial time the drainage lines were oriented in a general northeast-southwest direction, the result of the monoclinal ridge and valley topography of the area. No doubt, the drainage in northeastern Minnesota was quite different from that of today. It is probable that the body of water now known as Lake Superior did not exist in preglacial time. It is more likely that its present site was a broad lowland occupied by a river system. Before the ice-age, the streams in the area occupied broad open valleys of low gradient, such as characterize a region in an advanced stage in the cycle of erosion. The advent of the ice-sheets changed that condition; old streams were obliterated; others were forced to take new courses and entirely new streams came into being. Numerous lakes and swamps are now present where none existed before.

Many of the youthful post-glacial streams have cut deep, narrow gorges having numerous waterfalls and rapids. One cannot but be impressed by the size and depth of some of these post-glacial gorges. It may be that the enormous volume of melt-water from the shrinking ice-sheets was responsible for the rapid erosion necessary to produce gorges of such width and depth.

The Pigeon River has a comparatively low gradient in its lower course, as compared with the slopes of the smaller streams along the north shore of Lake Superior. This is accounted for by the fact that the Pigeon River is located principally on the Rove Slate which is weaker than the Keweenawan flows and intrusives. Pigeon River has an average gradient of 28 feet per mile in a distance of 30 miles. For a distance of one and one-half miles from its mouth, it has eroded its channel down to the level of Lake Superior, whereas the other streams tributary to the lake descend over rock ledges to points within short distances of the shoreline.

From a point above Partridge Falls about 20 miles from its outlet to one about 1.7 miles from its mouth, the Pigeon River descends through deep, narrow gorges by a series of waterfalls and rapids. From South Fowl Lake to Partridge Falls, a distance of 10.6 miles, the gradient of Pigeon River is only 11.3 feet per mile. Along the lower 20 miles the gradient averages 33 feet per mile. The gorge, cascades and falls are conspicuous where the river cuts through the resistant diabase sills and dikes. At High Falls (Fig. 4), the Rove Slate is intruded by a dike, trending N. 50 E., which forms the falls and a ridge on each side of the river. The fall of large masses of diabase from the face, resulting from prominent jointing, produces a vertical wall over which the water plunges a distance of 120 feet. The presence of a second dike, a short distance below High Falls is responsible for another cataract of lesser height. Partridge Falls, 50 feet high, was formed by the intrusion of a diabase dike into the Rove Slate.

On Pigeon River, about one and one-half miles northeast of Partridge Falls, is Split Rock Canyon, a deep narrow gorge cut for the most part in the Rove Slate. The river has cut its channel so rapidly since the recession of the ice-sheet, that little time has elapsed for widening the gorge by weathering and slope wash.

For a distance of about eight miles above Partridge Falls, the Pigeon River flows parallel to the diabase ridges and the escarpment formed by the Keweenawan flows, through a broad open valley on the Rove Slate, with continuous swamps to a point near the outlet of South Fowl Lake and up the Stump River lowland to Stump Lake. There is a great contrast in the course of the Pigeon River, below and above Partridge Falls; the marked difference of a broad, open swampy valley above the steep-sided, narrow gorges with cascades and waterfalls below that point. Apparently the post-glacial Pigeon River has not entrenched its gorge in the old preglacial valley above Partridge Falls.

The unusual course of the Pigeon River is the result of glaciation. As the ice-sheet receded, ponded waters were forced to the south of the ice front which found outlets through the lowest places, including the gaps in and between the diabase ridges where the present cascades and waterfalls are located. It is possible that the glacial waters followed the courses of minor streams which in preglacial time cut across the ridges through gaps or low places.

The preglacial Pigeon River may have drained through one of the broad valleys farther south, perhaps through the swampy lowland now occupied by Stump River and its continuation in a southeasterly direction. Or its route may have been through the old valley above Partridge Falls, following the lowland eastward from the site of Fort Charlotte and along the route through the gaps now followed by the Grand Portage trail which parallels the course of Grand Portage Creek to Lake Superior.

There is evidence to suggest that a preglacial stream existed on the site of the lower Pigeon River. Its mature valley in preglacial time passed through gaps in the diabase ridges similar to those northwest of Grand Portage. The preglacial streams that occupied the present sites of the lower Pigeon River and Grand Portage Creek, flowed through broad valleys where Pigeon Bay and Grand Portage Bay are now located. These rivers, doubtless, emptied into a larger stream which occupied the broad lowland now covered by Lake Superior.

Several factors combine to account for the falls on the north shore tributaries to Lake Superior. The first has to do with the gradual lowering of the lake level since the withdrawal of the ice-sheet from the Lake Superior basin. According to Leverett,[3] the elevations near Grand Marais indicate the highest beaches at 1,206 to 1,275 feet above sea-level or 604 to 623 feet above the present level of Lake Superior. The Algonquin beaches are present at Grand Marais at 1,042 feet above sea-level. Several lower levels are indicated at 785, 760, 725 and 630 feet above sea-level in the same locality.[4] North of Hovland, the upper limit of lake action is about 1,300 feet. At Pigeon River, the upper limit is slightly above that at Hovland and at Mt. McKay at Fort William, Ontario, the highest beach level is 1,350 feet above sea-level or 748 feet above the level of Lake Superior.

According to Leverett[2], the highest beaches at Duluth appear at about 1,135 feet and the lowest at not more than 1,085 feet. The lake levels at Duluth are 60 feet higher than on the south side of the lake, in a distance of 24 miles. It appears that there has been differential uplift of two and one-half feet per mile since the recession of the ice. Leverett points out that the differential uplift of the highest beach, from a point near Schroeder to Poplar River is 33 feet in 13.3 miles or 30 inches to the mile, along the course of the beach. The rate is nearly as great from Lutsen to Grand Marais or to the hill northwest of Hovland where the highest beach is 1,300 feet above sea-level.

The high level of Lake Duluth would bring the water up on the upland to the north. As the level dropped, the gradient to the north shore tributaries was increased. Each successive drop in lake level, produced a sharp rejuvenation at their mouths. Furthermore, the gradual differential uplift and tilting of Lake Superior and its predecessors has produced results favorable to the constant rejuvenation of the streams flowing into Lake Superior from the north. One should not underestimate the importance of the tremendous erosion accomplished by the ice lobe which occupied the Lake Superior lowland and its effect in the steepening of the adjacent slopes. Glacial erosion may have produced hanging valleys along the north shore.

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[3]Idem. 1, p. 59.

[4]Grout, F. F., and Schwartz, G. M. Rove Formation, Minnesota Geological Survey, Bulletin 24, p. 10.

The steep shores of Lake Superior have been attributed to faulting. In the writer's opinion, not enough emphasis has been placed on the effects of glacial erosion in the Lake Superior trough. The lake basin was deepened and its sides eroded, producing on the north side, a steep regular slope which has been modified by the waves and currents since the ice-age.

A feature which can be pointed out here, is that the convex profile of the north shore tributaries to Lake Superior is significant.[4] This is interpreted by the writer as an indication that the erosive power of the streams has not been able to keep pace with the rise of the land.

[4]Idem. 1, Profile of the St. Louis River, Figure 3, p. 9.